

INFLUENCE OF SURFACE-ACTIVE SUBSTANCES ON THE COAGULATION OF AEROSOLS

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Vapors of extraneous substances when present in air cause a complication in aerosol processes which so far has not been studied, in spite of the practical and theoretical importance of the question. A number of authors (1-7) have produced evidence that the presence in air of surface-active substances (phenol, oleic acid, etc.) does influence the coagulation of aerosols quite considerably. To explain their findings, these authors have advanced the poorly founded hypothesis that the vapors of surface-active substances are capable of forming an adsorption of gaseous type around the aerosol particles, a layer which is alleged to be stably bound thereto and able to increase the stability of the aerosol by converting it into a system similar to a protected sol.

The aerosols studied were in very heavy concentrations and were produced directly in the "previously prepared" vapors of the surface-active substances. The dispersions of the aerosols was in most cases measured by sedimentation tests. Later it was noticed that no variations were exhibited when phenol vapor acted on Fe_2O_3 aerosol.

We have studied the effect of phenol and oleic acid vapors on the coagulation of oil-fog and stearic acid aerosols.

The aerosols were produced by thermal condensation in apparatus which we constructed especially for the purpose. Oil-fog was produced in the apparatus shown in Figure 1, in a manner which ensured results of satisfactory duplicability.

Oil was fed from microburette M into the heated metal plate N in the metal stove A. Through tube E a stream of heated filtered air was led in at a velocity of 0.2 l/min. In the stove this air became saturated with oil vapor. In tee-connection B the oil vapor was diluted in a stream of cold air flowing at a velocity of 40 l/min. The supersaturation thus induced in the diluted stream caused the formation of an aerosol. This aerosol was led into a chamber previously filled with the vapor of the surface-active substance. After mixing with a fan, it was subjected to test.

Shield C and the air-cooling effect in pipe B prevented the diluted stream from being reheated more than $1.5^{\circ}C$ (at stove temperature $230^{\circ}C$). Thus the supersaturation temperature of the vapor was maintained practically without change. The stove temperature, read from thermometer T, fluctuated by not more than + or - $0.5^{\circ}C$. Oleic acid aerosol was produced in the apparatus shown in Figure 2. An exactly weighed portion of stearic acid was sprinkled along with previously roasted sand into a hollow cut in an asbestos stopper, in which a spiral platinum wire C was mounted. A stream of filtered air was passed through tube A at a velocity of 40 l/min. In the air stream through the tube an aerosol was formed and was led into the test chamber, which had been previously filled with foreign vapor. The stearic acid was volatilized by heating the spiral platinum wire with an electric current; the degree of heating was checked with a voltmeter.

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Our methods of producing the aerosols, and likewise our test procedure, were free of a number of errors which previous authors had permitted in their work (1, 3-7). In our tests, we established conditions such that no processes other than aerosol coagulation took place in the aerosols in the presence of the foreign vapors. We approximated this essential requirement as follows:-

- (1) by seeing to it that the condensation of the aerosol took place in pure air, thus excluding possibility that the foreign vapor might influence the process of aerosol formation;
- (2) by seeing to it that no process of aerosol sedimentation was taking place during the time we were making our tests; this condition was met by having a small initial concentration of a highly dispersed aerosol with particles sufficiently homogeneous in size (the absence of aerosol sedimentation was checked with a micro-balance with a sensitivity of 10^{-6} g);
- (3) the method we used for introducing the foreign vapor into the chamber, namely that of blowing it off the surface of a liquid in a closed vessel in a constant temperature chamber, excluded all chances of distorting our results by the condensation of the vapor itself during the time we were taking our readings; it also made it possible to introduce with sufficient exactitude the requisite quantity of vapor into the chamber and to distribute it uniformly throughout the volume of the chamber.

Particle counts were made in a gas cell, in a manner free of errors of method, thanks to the use of a specially adapted ultramicroscope.

The particle radius in our experiments was of the order of 10^{-5} cm. The concentration of the aerosols by weight was 25 mg/cm^3 ; the concentration of the vapor in the chamber varied from 0.5 mg/m^3 to complete saturation.

Figure 3 where the abscissa is time and the ordinate is particle volume, shows coagulation curves contained by us. Our findings for coagulation in pure air are given in the form of black dots, those for coagulation in the presence of foreign vapors, in the form of circlets. As may be seen from this figure, both systems of points, those obtained for pure air as well as those obtained with foreign vapors present lie on a single straight line, a fact which indicates that aerosol coagulation in the presence of foreign vapors proceeds in exactly the same way as when they are absent.

The conclusion which emerges is that there evidently can be no retardation of the speed of aerosol coagulation by adsorbed layers formed by surface-active substances around aerosol particles. Nevertheless one may expect some retardation of the coagulation speed under the influence of foreign vapors in those cases where adsorption or absorption of these vapors causes a marked change in the shape of the aerosol particles. This was an effect we observed with ammonium chloride in the presence of water vapor, on this we shall make a detailed report in a later paper.

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